Carbohydrates & protein digestion

Carbohydrate Residue	**Enzyme of digestion**	Type of bond	Products	Others
Cellulose	**not digestible**	β-1,4 glycosidic		It increases the bulk of stool & and prevents constipation
Polysaccharides (Starch/ Glycogen)	**Pancreatic/ salivary amylase**	α-1,4 glycosidic	Dextrins/ maltose/ isomaltose (it is an endoglucosidase= cannot give free glucose)	Pancreatic amylase is the main digestive enzyme for carbohydrates
Maltose	**Maltase**	α-1,4 glycosidic	2 Glucose molecules	
Isomaltose	**Isomaltase**	α-1,6 glycosidic	2 Glucose molecules	
Sucrose	**Sucrase**	α-1,2 glycosidic	Glucose + Fructose	
Lactose	**Lactase**	β-1,4 glycosidic	Glucose+ Galactose	

Lactose intolerance:

Causes: **Lactase deficiency**
1-Congenital or primary: due to a defect in the gene producing the enzyme.
2-Acquried or secondary (adult hypolactasia); the most common type: due to damage of intestinal brush border intestinal enzymes due to: GIT surgery, Gastroenteritis, Chemotherapy, or may be Age-dependent

Symptoms: diarrhea, abdominal distention and cramping **following intake of milk and dairy products.**

Biochemical basis:
1. The osmotic effect of the undigested and unabsorbed lactose leads to an influx of fluid in the lumen of the small intestine → diarrhea with its abdominal distention and cramping.
2. The bacteria in the colon ferment the lactose → gases and acids→ flatulence

Diagnostic tests:
1. Hydrogen Breath Test→ increased
2. Stool Acidity Test
3. Mucosal biopsy confirms the diagnosis.

Treatment:
1. Intake milk-deficient in lactose as Soy milk
2. Intake of yogurt (Partly digested dairy products by bacteria decrease lactose content)

3. Lactase enzyme drops or tablets (Yeast tablets) prior to eating
4. Treat the cause in secondary type
5. Getting enough calcium and vitamin

Sucrase-Isomaltase deficiency:

- These 2 enzymes are synthesized on a single polypeptide chain, hence, their deficiencies coexist.
- Presents with the same manifestations as that of lactose intolerance (but following Sucrose containing food e.g. sweets and fruit juice)
- History confirms the diagnosis. Most confirmatory test is mucosal biopsy.

Digestion and absorption of proteins:

- Most of these proteolytic enzymes are secreted as **zymogens** (Pepsinogen, trypsinogen, chymotrypsinogen, proelastase, and procarboxypeptidase are precursors for pepsin, trypsin, chymotrypsin, elastase, and carboxypeptidase respectively).

- **Absorption of amino acids:** Active transport; a protein carrier mediated - system requiring ATP obtained from Na^{+}/ K^{+} ATPase.

Phase	Enzyme	Type	Specificity (hydrolyzes the peptide bond adjacent to
1- Gastric	Pepsin	endopeptidase	**Acidic** a.a. (Glu, Asp).
2- Pancreatic	Trypsin.	endopeptidase	**Basic** a.a. (Arg, Lys)
	Chymotrypsin	endopeptidase	**Aromatic** a.a. (Phe, Trp)
	Elastase	endopeptidase	**Non-polar** a.a. (Gly, Ala)
	Carboxy-peptidase	Exopeptidase	The **C-terminus**
3- Intestinal	Amino-peptidases	Exopeptidases	The **N - terminus**.
	Tri-peptidases & Di-peptidases		Act on **tri- & dipeptides**; producing free amino acids.

Digestion and absorption of fat

Dietary fats:

- Saturated fats (90%): TAG, cholesterol esters
- Unsaturated fats: MUFAs, PUFAs.
- Trans fats: should be <1%

Lipid	**Enzyme of digestion**	Products	Others
TAG with short to medium chain FA	**lingual and gastric lipases** (acid stable)		they have an important role in: 1. **Neonates**, as the milk fat is the primary source of calories+ it contains TAG with short to medium chain FA (It has a little significance in adult stomach; more acidic than neonates) 2. Individuals with pancreatic insufficiency such as those with **cystic fibrosis** (CF) (defective in chloride channels → thickened secretions → obstruct the pancreatic ducts→ absence of pancreatic lipase.
TAG	**Pancreatic lipase**	2-MAG + 2FFAs	• It is helped by bile salts and $Ca^{2+.}$ • It needs colipase (a small protein secreted by pancreas) to be active.
Cholesteryl ester:	**Pancreatic cholesteryl esterase**	Cholesterol + FFAs.	It is helped by bile salts and $Ca^{2+.}$
Phospholipids	**PLA2, then lyso-phospholipase**	glycerylphosphoryl-choline	It is helped by bile salts and $Ca^{2+.}$

Emulsification of dietary lipid in duodenum:

- It increases the surface area of the hydrophobic lipid droplets so that the digestive enzymes can act effectively.
- It is done by peristalsis and **bile salts** (that are made in the liver and stored in the gallbladder).

Explain on biochemical basis mechanism of action of Orlistat as anti-obesity drug

Orlistat, an anti-obesity drug, inhibits gastric and pancreatic lipases, thereby decreasing fat absorption, resulting in weight loss. So it prevents fat absorption including fat soluble vitamins (A, D, E, K) and leads to its deficiency manifestations (e.g. epistaxis)

Absorption of lipids by enterocytes:

- Short- and medium-chain Fas are water soluble → directly absorbed by the intestinal mucosa **(Explain: dietary therapy of short- and medium-chain in lipid malabsorption conditions)**

- **Formation of micelles:** the remaining products of digestion (FFA, cholesterol, and 2-MAG) + bile salts and fat-soluble vitamins (A, D, E, and K) form the amphipathic micelles (inside hydrophobic & hydrophilic outside and soluble in aqueous environment of the intestine)

- **Cholesterol** is poorly absorbed by the enterocytes and **ezetimibe** (a drug) can further reduce cholesterol absorption in the small intestine

- **Incorporation in chylomicron** (Secretion): TAGs and CE are very hydrophobic and Apo-B48 stabilizes & increases the solubility. Then, chylomicrons are exocytose into lacteals of lymphatic system to the thoracic duct, and then finally to the blood causing turbidity **(Post-alimentary hyperlipidemia)**

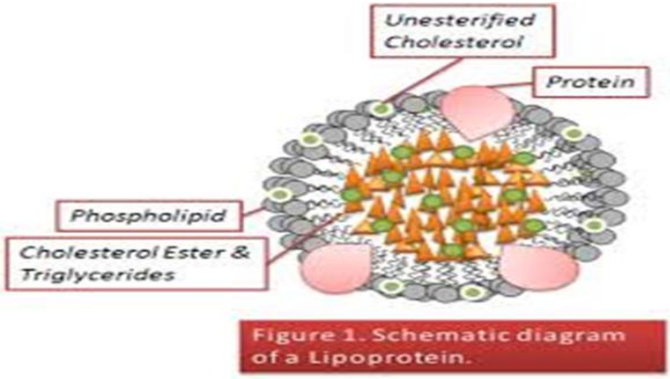

Figure 1. Schematic diagram of a Lipoprotein.

Pathological conditions affecting fat digestion and absorption:

Steatorrhea: the presence of excess fat in feces (fatty diarrhea, fatty stool, milky stool)

Causes:

1. Deficiency of **Pancreatic lipase or** co-lipase e.g. pancreatitis…etc.
2. Deficiency of **Bile salts** e.g. Obstruction of bile duct (stone or cancer head of pancreas), cholecystitis and hepatitis or liver cell failure or hepatocellular carcinoma).
3. Any disease affecting **intestinal absorption** as gastroenteritis or malabsorption syndrome.